Research of Image Segmentation on Pulmonary Nodules in PET-CT Image Based on LIBSVM

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Abstract:

Nowadays, it’s still hard to segment the Pulmonary nodules with others in PET-CT image. In this paper, to the Pulmonary nodules in PET-CT image, we use the method of LIBSVM to extract. As SVM having unique advantage in the problem of nonlinear identification, and there are more default parameters and less parameters adjustment in SVM when using LIBSVM, it’s rapid and accurate to use LIBSVM to extract the Pulmonary nodules in PET-CT image. In the experiment of this paper, we use RGB values and grayscale statistics of eigenvalues as different set of characteristics to extract the same Pulmonary nodules in PET-CT image. The experimental results show that, in the cost of time and accuracy of classification, LIBSVM using grayscale statistical characteristics is more accurate, and the performance of classification is better.

Keywords: LIBSVM, PET-CT, Pulmonary Nodules, Image Segmentation

1. Introduction

With the development of biomedical engineering and computer technology, there are many multiple medical images for the clinical diagnosis through medical imaging, the traditional medical image segmentation still remains at the level of human-computer interaction, the processing time is long, and the results of processing might be impacted by different human factors. Therefore, how to achieve the automatic segmentation of medical image, especially the PET-CT images, is the focus of research in medical image[1].

While the processing of PET-CT medical image still do not get very good settlement today, a large part of reason is the complexity and diversity of PET-CT medical image[2]. As the different organization has different characteristic, formation of the PET-CT image could be affected by such as organization motion, body effect, noise and so on, and especially the process of image registration between PET and CT will inevitably have tiny errors. Therefore, compared with general medical images, there are more problems such as asymmetric and fuzzy in PET-CT medical images[3].

Support Vector Machines (SVM), it was first proposed by Cortes and Vapnik in 1995[4], used for classification and regression analysis. In solving small sample, nonlinear and high dimensional pattern, SVM has many unique advantages, and it could be used in other problems of machine learning such as function fitting. Support Vector Machine constructs a hyperplane or set of hyperplanes in a high- or infinite-dimensional space, which can be used for classification, regression, or other tasks. Intuitively, a good separation is achieved by the hyperplane that has the largest distance to the nearest training data point of any class[5]. LIBSVM is designed by Lin Chih-Jen in National Taiwan University, it’s an integrated software for support vector classification, (C-SVC, nu-SVC), regression (epsilon-SVR, nu-SVR) and distribution estimation (one-class SVM)[6]. It supports multi-class classification. Scholar could easily use SVM through LIBSVM as a tool, and LIBSVM provides a simple interface where users can easily link it with their own programs. It provides a lot of default parameters, you can use these to solve a lot of problems, and it also provides the Cross Validation function[7].

This paper relies on the reliability, convenience and superiority of LIBSVM in dealing with nonlinear small samples and high dimensional data. According to the characteristics such as discontinuous boundary and uneven gray of PET-CT medical image, we do research in depth on the...
applications of LIBSVM used in processing the PET-CT medical images, especially the PET-CT medical images of pulmonary nodules\cite{8}.

2. Basic theory of support vector machines

Support Vector Machine is based on the linear division. But it is obvious that, not all of the data could be divided linearly. For instance, two categories of points in two-dimensional space, as follows:

![Figure 2.1 The point can not be divided linearly in two-dimensional space](image1)

Obviously, you can’t use a straight line to divide these points, it must be a curve. The principle of SVM is that it could project the points in low-dimensional space onto a high-dimensional space. As a result of that, we will make the linear inseparable point become linearly separable, then classify the boundary according to the principles of the linear division. As follows:

![Figure 2.2 Projecting the points in low-dimensional space onto a high-dimensional space](image2)

However, our discussion of SVM is based on the optimization problem rather than the algorithm of projecting the points in low-dimensional space onto a high-dimensional space\cite{9}.

SVM originally derived from the processing of data classification, it’s to look for a split plane, which is able to make the point of the training set as far as possible from it, and make the classification interval (margin) as large as possible\cite{10}. 
According to the case showed in Figure 1.3, solid points and hollow points denote two types of training sample, H is the line which classifies these two types without error. H1 is a straight line parallel H, it passes through the one which is nearest to H in solid points, H2 is the similar line as H1. The distance between H1 and H2 is called classification interval (margin) of these two types. The optimal classification line not only requires that it could divide those two types separately, but also make the margin largest. In Figure 1.3, the optimal classification line can be understood as H, the points on H1 and H2 are called support vector because they support the optimal classification line [11][12].

When we use LIBSVM, we need to get these support vector as training samples (TrainData), and then we should build predictive models through LIBSVM and achieve the optimal hyperplane, which we can use to classify the test samples (TestData).

3. The experiments in pet-ct image segmentation of lung nodules based on libsvm

Separating and extracting a specific area from the image is called image segmentation. The image segmentation of PET-CT could extract an area we need, usually that is lesion, which will assist doctors in analyzing quantitatively and qualitatively. Therefore, PET-CT medical image segmentation has been attached great importance, then a variety of different segmentation methods have been produced, and their basis are not uniform. But subject to the complexity and diversity of PET-CT medical images, most technology of image segmentation does not achieve the desired results. LIBSVM is good at solving nonlinear identification problem, and it’s not sensitive to the discontinuity of characteristic, so using LIBSVM to segment PET-CT medical image can achieve better results than the other algorithms.

The experiment of this article is based on MATLAB, extract the lesion from PET-CT images of pulmonary nodules through the LIBSVM algorithm. We must first select which features as the feature set of training samples before use LIBSVM. There are two principles: Identity and independence. Identity means the category of the feature set should be same, and Independence means the feature set of different samples is independent of each other.

In this paper, we selected two different categories as the feature set: The RGB values of a point in the image and the gray scale statistical values of a point in the image, including the gray-scale value, the gray median value and average gray value.

Set RGB values as the feature

In this part, we will use the ginput function in MATLAB to sample by mouse clicking. In this experiment, RGB values of the point in PET-CT is set as the feature of sample, and the frequency of sampling is 40 times. We use these samples as the TrainData of LIBSVM, the TrainData is 40*3 matrix.
As we can see from the Table 3.1, row vector represents the RGB values of each point. We set the label value of first 20 of TrainData as 1, and set last 20 as -1. According to these, we could carry out the prediction function (Svmpredict), and construct the hyperplane to classify. The result is as follows:

**Table 3.1** 10 samples selected from the TrainData

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![Figure 3.1 The results obtained by LibSVM](image1)

**Figure 3.1** The results obtained by LibSVM

![Figure 3.2 TestData](image2)

**Figure 3.2** TestData
We can see the test samples (TestData) and the divided images obtained by LibSVM from the Figures 3.1 and 3.2. In Figure 3.1, left is the initial PET-CT medical image, we extract the highlighted part (lesion site) and its information through the training (svmtrain) and prediction (svmpredict) by LibSVM, the effect is very obvious.

However, the unsatisfactory of this experiment is also obvious. As using RGB values as the feature of sample, the effect is not satisfactory in the edge extraction. To the complex image such as medical image, we should set the better one as characteristic feature to constitute samples of support vector machine in order to ensure the identity and independence of the sample distribution. According to the current research in this area, segmenting medical image through local gray statistical characteristics could obtain better results.

Set the gray statistical characteristics as the feature

In the experiment of this part, we will extract the gray-scale value of the current pixel, the gray median of the current pixel neighborhood, and the average gray value of the current pixel neighborhood as the feature of LibSVM from the PET-CT medical image of pulmonary nodules. In order to obtain the local features, we need to make the neighborhood of current pixel form a window, and then extract local gray statistical characteristics in this window. If the window is too small, we can’t get effective information; However, if the window is too large, then there will be different texture information contained in same window. Therefore, we finally select the window size 5*5 in our experiment of processing of PET-CT medical images after contrast different size of the window.

This experiment is based on the experiment before, still use the ginput function in MATLAB to sample by mouse clicking, and the frequency of sampling is 40 times. We set the gray-scale value of the current pixel, the gray median of the current pixel neighborhood, and the average gray value of the current pixel neighborhood as the TrainData, so the TrainData is also 40*3 matrix.

### Table 3.2 10 samples selected from the TrainData

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In Table 3.2, we can see that, the row vector represent the gray-scale value of the current pixel, the gray median of the current pixel neighborhood, and the average gray value of the current pixel neighborhood. Use these training samples to carry out the prediction function (svmpredict) and construct hyperplanes to classify. The results are as follows:
Figure 3.3 The results obtained by LibSVM

Figure 3.4 TestData

Figure 3.5 The contrast between the results based on the standard of RGB values and gray statistical characteristics values
As we can see from Figure 3.5, the result based on the standard of gray statistical characteristics is much better than the one based on the standard of RGB, especially on the segmentation of edge, it’s more refined, and the effect is also more pronounced.

4. Conclusion

Nowadays, there are many scholars working on the application of SVM in image processing, but most of them still remain in the ordinary images, and less in application of medical image processing. In our paper, we extend the application of SVM, segment the pulmonary nodules in PET-CT medical image through LibSVM based on the feature of RGB values and gray statistical characteristics values. Experimental results show that the number of training samples of LibSVM hardly affect the performance of segmentation. The execution time of this algorithm is short, it has high accuracy and excellent effect of segmentation. Therefore, to the complex image such as PET-CT medical image, the method of LibSVM is a good choice, it has high efficiency and low error rate in classification.

5. References